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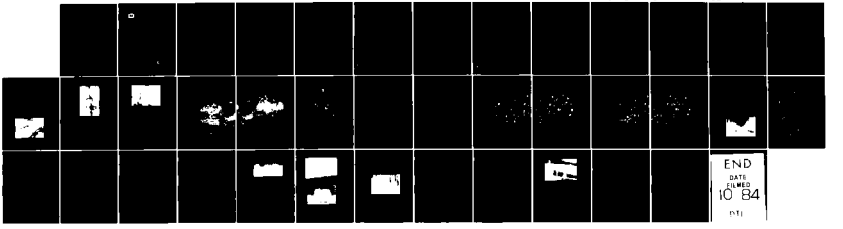

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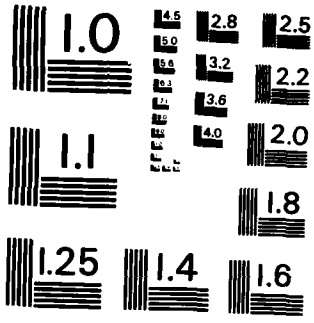

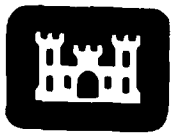

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BIOMASS ENERGY SELF-SUFFICIENCY RESOURCE ALTERNATIVES FOR A FORESTED AIR FORCE INSTALLATION

FINAL REPORT

Ultrasystems, Inc.
10340 Democracy Lane
Fairfax, Virginia 22030

May 1982

Prepared for:
US Army Facilities Engineering Support Agency
Technology Support Division
Fort Belvoir, VA 22060

TECHNICAL REPORT

BIOMASS ENERGY SELF-SUFFICIENCY RESOURCE ALTERNATIVES FOR A FORESTED AIR FORCE INSTALLATION

PREPARED FOR

U.S. ARMY
FACILITIES ENGINEERING SUPPORT AGENCY
FOR BELVOIR, VIRGINIA 22060

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This study was sponsored by the U. S. Air Force to determine the options available that would provide a cost-effective, practicable means for energy management of the forested lands of Eglin Air Force Base. The options proposed are structured to provide the appropriate fuel wood quantities required to support basewide biomass energy systems. The study confirmed the feasibility of a biomass energy plantation supplying the required fuel wood to support the basewide biomass energy systems while, at the same time not conflicting with any of the operational missions of Eglin AFB. This

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20. conclusion is based on a comparative analysis of five possible energy plantation options and their associated yields with respect to species and optimal silvicultural practices. Three of the plantation options were eliminated for various reasons. One was considered as effective, and one was deemed as being superior. The superior option will provide enough timber, after the initial cycle has been completed, to maintain the merchantable timber at desired levels and to more than adequately supply the fuel wood requirements to insure that Eglin AFB is energy self-sufficient. This will enable the Air Force to have an installation that provides all of its electrical and thermal energy requirements through the utilization of the Biomass Energy Island concept.

EXECUTIVE SUMMARY

The "Energy Crisis" has manifested itself in high energy costs, supply interruptions, inadequate allocation of crude oil, and shortages of products based on crude oil. From a national security standpoint these factors of uncertainty dictate that alternative, renewable energy sources be exploited.

The Air Force was quick to realize the vulnerability of its installations to fossil fuel interruptions. In June through August 1978 a study was conducted to evaluate the feasibility of using wood grown on selected Air Force installations as the fuel to supply the entire heating requirements of each of those installations, thereby replacing the conventional fossil fuels currently being used. This study, Forestry Lands Allocation for Managing Energy (FLAME) identified six Air Force installations having the potential for supplying significant portions of their heating energy requirements based on nonmerchantable timber grown on their respective installations.

The FLAME concept was substantially expanded to consider the ability of one installation to meet its total facility energy requirement for an indefinite period of time using its own biomass resource, without internal energy supply. This expanded concept is termed a Biomass Energy Island (BEI). A study addressed the technical issues of interfacing biomass systems with in-place energy systems and found that Eglin AFB had the highest technical and follar payoff potential. The investigation confirmed that a biomass energy island system could be achieved through a centralized biomass gasification/combined cycle system to produce 135,000 lb/hr 150 psig steam (saturated) and 27 Mwh/hr electrical power from 540,000 green tons of wood chips. This study further extends the previous studies with an evaluation of the forested and non-forested lands of Eglin AFB in terms of use, stability, quantities available to be placed into energy plantations and options for the energy plantions.

The study identifies and quantifies 98,800 net producing acres that can be adequately managed and placed into biomass energy plantations that have the capability of supporting Eglin AFB as a Biomass Energy Island. This acreage will be available for use as energy plantations on a long-term basis with little or no interference with any military operations or exercises.

Five energy plantation options were developed and evaluated for Eglin Air Force Base's particular circumstances:

- Option 1 - High energy subsidy, Intensive crop management
- Option 2 - High energy subsidy, Sewage effluent application with intensive crop management
- Option 3 - Low energy subsidy, Single species modified/ conventional management
- Option 4 - Low energy subsidy, Dual species modified/ conventional management

- Option 5 - Low energy subsidy, Select single species short rotation management

All of the options presented, except number one, have potential for use at Eglin. The final operating Biomass system could incorporate the remaining four options into an integrated biomass management system utilizing to their best advantage the production opportunities as they occur. The single option selected as s uperior for Eglin's characteristics and need is Option 5, low energy subsidy with Choctawhatchee sand pine on lakeland soils.

PREFACE

This report was prepared by Ultrasystems, Inc., Washington Operations, 10340 Democracy Lane, Fairfax, Virginia 22030, for the U.S. Army Facilities Engineering Support Agency, Fort Belvoir, Virginia 22060. The project was sponsored by the Air Force Engineering and Services Laboratory, Headquarters Air Force Engineering and Services Center Tyndall Air Force Base, Florida 32403, as part of the Air Force Facility Energy Research and Development Program under Program Element 64708F, Project 2054 (Aerospace Facilities Engineering Development), Task 5 (Aerospace Facility Power System).

This report documents work performed during the period July 1981 to January 1982. The Project Officer was Mr. Stephen A. Hathaway.

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Mr. Robert W. Britt, Chief, Natural Resources Planning Section, Eglin AFB
Mr. J. Neil Hoskins, Forester, Eglin AFB
Mr. Steven M. Seiber, Forester, Eglin AFB
U.S. Forest Service
Florida Division of Forestry

This report has been reviewed by the Information Officer and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

Signature
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Title (Project Engineer/Scientist)

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NAME
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NAME
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Title (Director)

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SECTION I

INTRODUCTION

1. BACKGROUND

The fall of 1973 was the beginning of what is commonly called the "Energy Crisis." The perpetuation of this problem over the last eight years has created and fueled a potentially volatile global situation which has effected every aspect of life in the industrial nations. The emerging countries, that are attempting to become stable and enter the international community, are also being hampered by the uncertainty and high costs. This situation has demonstrated to the entire world that the United States was, and still is, too dependent upon uncertain supplies of imported oil. The United States is in a visibly vulnerable position in the world at the time when, due to the global political and economic instability, it can least be afforded.

Energy security is important to the United States but is mandatory for the armed services. A viable alternative for the military, in applications which are not liquid fuel dependent, is locally available energy sources such as renewable biomass. The Air Force was quick to realize the vulnerability of its installations to fossil fuel interruptions and in 1978 they embarked on an in-house study to evaluate the feasibility of biomass utilization. This study, Forestry Lands Allocated for Managing Energy (FLAME), ascertained that Eglin AFB and several other installations had the potential for supplying significant portions of their energy requirements with non-merchantable timber grown on the base. A follow-up to the FLAME study addressed the technical issues of interfacing biomass systems with in-place energy systems and found that Eglin had the highest technical and dollar payoff potential.

The follow-on to the FLAME study proposed four sequentially greater biomass energy systems for Eglin Air Force Base. The initial systems, using two different technologies, were selected to allow for the demonstration and comparison of separate methods of biomass conversion to energy in full, online operation. Demonstration Module: Option 1, is a gasification, combined cycle system producing 5,000 lbs/hr steam at 150 psig (saturated) and 4 MwH/hr electricity from a fuel wood feedstock of 170 green tons per day. Demonstration Module: Option 2, is a direct combustion, cogeneration system producing 105,000 lbs/hr steam at 150 psig (470°F) and 2 MwH/hr electricity from a fuel wood feedstock of 480 green tons per day. The two initial systems can be implemented sequentially or together.

The third system, a combination of the two initial systems, has capacity sufficient to satisfy the Eglin Air Force Base Main Base complex. The parameters are additive and amount to 110,000 lbs/hr steam at 150 psig and 7 MwH/hr electricity from 650 green tons of wood chips per day.

The fourth energy system, sized to satisfy the Biomass Energy Island (BEI) concept (supply the facility energy for the entire base), is a centralized biomass gasification, combined cycle system which is an add-on to the Main Base system. The add-on will produce 25,000 lbs/hr steam at 150 psig and 20 MwH/hr electricity. The combined output will be 135,000 lbs/hr steam

at 150 psig and 27 MwH/hr electricity produced from 1,480 green tons of wood chips per day.

The generated energies and the biomass demands of the four systems proposed are summarized in the chart below:

SYSTEM	GTPD*	GTPY* (1000)	ENERGY OUTPUT
DEMONSTRATION MODULE OPTION #1	170	62	4 MWHR/HR 5,000 LB/HR; 150 PSIG (SAT) STEAM
DEMONSTRATION MODULE OPTION #2	480	175	3 MWHR/HR 105,000 LB/HR; 150 PSIG, 470°F STEAM
MAIN BASE	650	237	7 MWHR/HR 110,000 LB/HR; 150 PSIG STEAM
ENTIRE BASE	1,480	540	27 MWHR/HR 135,000 LB/HR; 150 PSIG STEAM

*GTPD/GTPY = GREEN (50% MC) TONS PER DAY/PER YEAR

This study is based upon the BEI requirement of 540,000 green tons of fuel wood per year and is the next step leading to the development and implementation of the BEI concept which will provide secure energy sources to the Air Force.

2. OBJECTIVE

The objective of this study is to develop and recommend a cost-effective, practicable means by which Air Force forested lands can be managed in order to supply the appropriate fuel wood quantities required to support basewide biomass energy systems. The results of this effort can be applied within the Air Force Facility Energy and Resource Conservation Program in a larger-scale effort oriented toward the development of data to support airbase biomass energy self-sufficiency, i.e., the Biomass Energy Island concept.

3. SCOPE

The study focuses on Eglin AFB, Florida, as a model BEI location and separates the effort into several distinct, but related, categories. The study addresses the current use of Eglin's land area; and determines the base's acreage which is available for a biomass energy plantation: five biomass energy plantation options were developed and discussed and a superior option is recommended. Species and species mix for cultivation are specified and optimal silvicultural practices are suggested.

4. APPROACH

Methodology for gathering the extensive amount of data required to produce the plantation options, processing the evaluations, and providing the recommendations was kept as simple and straightforward as possible. Extensive research was conducted into local aspects such as soil type and condition, indigenous and introduced species, basic environmental concerns and base operations, etc. These results were then combined with an interview/field survey procedure which provided a means of obtaining, analyzing, and verifying the data.

This procedure began with a briefing/interview between the field team and appropriate base personnel. The initial meeting was arranged several weeks in advance as to attendance, format, and topics to be covered. The results of this meeting provided the framework by which the field survey would be structured and a definitive starting point for an initial ground survey was established. This ground work was then followed by an aerial survey of the base, a second ground survey, and a close-out meeting/interview.

5. SUMMARY

This study has identified and quantified 98,800 net producing acres that can be adequately managed and placed into biomass energy plantations that have the capability of supporting Eglin AFB as a Biomass Energy Island. This acreage should be available for use as energy plantations on a long-term basis with little or no interference with any military operations or exercises. With proper planning and management, the Biomass Energy Island concept can become a reality at Eglin without adverse effects on the environment, the wildlife, or the special interest archeological, historical, and geological areas. In fact, a properly coordinated, intensive program of forest management would increase system diversity and balance, enhancing both the productivity and vigor of the involved ecosystems.

SECTION II

ACREAGE ASSESSMENT OF EGLIN AFB

1. INTRODUCTION

The Technical Report Advanced Bio-Energy Systems for Air Force Installations dated October 1981 describes the energy systems needed to provide all facility energy requirements at Eglin AFB. It also briefly discusses the availability of forest biomass needed to supply these systems, focusing chiefly on forest residues as the prime source of energy feedstock. The analysis which follows concerns itself with the options available on the lands of Eglin AFB for biomass production. In so doing it moves beyond the October 1981 report, shifting the emphasis from the use of forest residues to the planned growth and harvesting of energy biomass as a function of forest management on these lands.

In a study effort of this type it is necessarily imperative to thoroughly understand the nature of the area involved. For this reason, the acreage on Eglin AFB had to be identified by type of usage within the categories of forested and non-forested acreage, and, of equal importance, the long term stability of the identified acreage also has to be determined.

2. FORESTED ACREAGE

Elgin AFB is an extremely large installation of over 464,000 acres. Approximately 87% of its total area, or over 403,700 acres, has some form of forest cover. This forest cover ranges in type from sparce scrub oak and

Figure 1. Aeriel View - Scrub Oak and Managed Timber Stand.

Figure 2. 25 Year Old Planted Sand Pine.

undergrowth to managed plantations of mature pine that is thirty-five years old. (Figures 1, 2 and 3).

The area of Eglin Air Force Base is used in many different ways, both for military and non-military purposes. Militarily, the forested areas are utilized for three basic functions: testing areas, firing ranges, and ground maneuvers (Figure 4). The area used for the testing and firing ranges amounts to approximately 58,000 acres and cannot be utilized as part of the energy plantation. The size of the areas utilized for maneuvers will vary from a relatively small area that may be used in training by the Army's First Ranger Company, to an area that encompasses virtually the entire base (as occurred in the October - November time period for a joint readiness exercise). These areas are viewed as possibles for inclusion into the energy plantations on a limited activity basis.

The non-military use of the forested areas can be categorized into three overlapping groups: protected/restricted areas, recreational areas, and managed timber areas. The protected/restricted areas fall into four sub-categories of historical, biotic, geological, and archeological. These areas are located throughout the base. There are no historical structures on the base that meet the federal or state specifications, but there are numerous

Figure 3. 35 Year Old Natural Timber Stand.

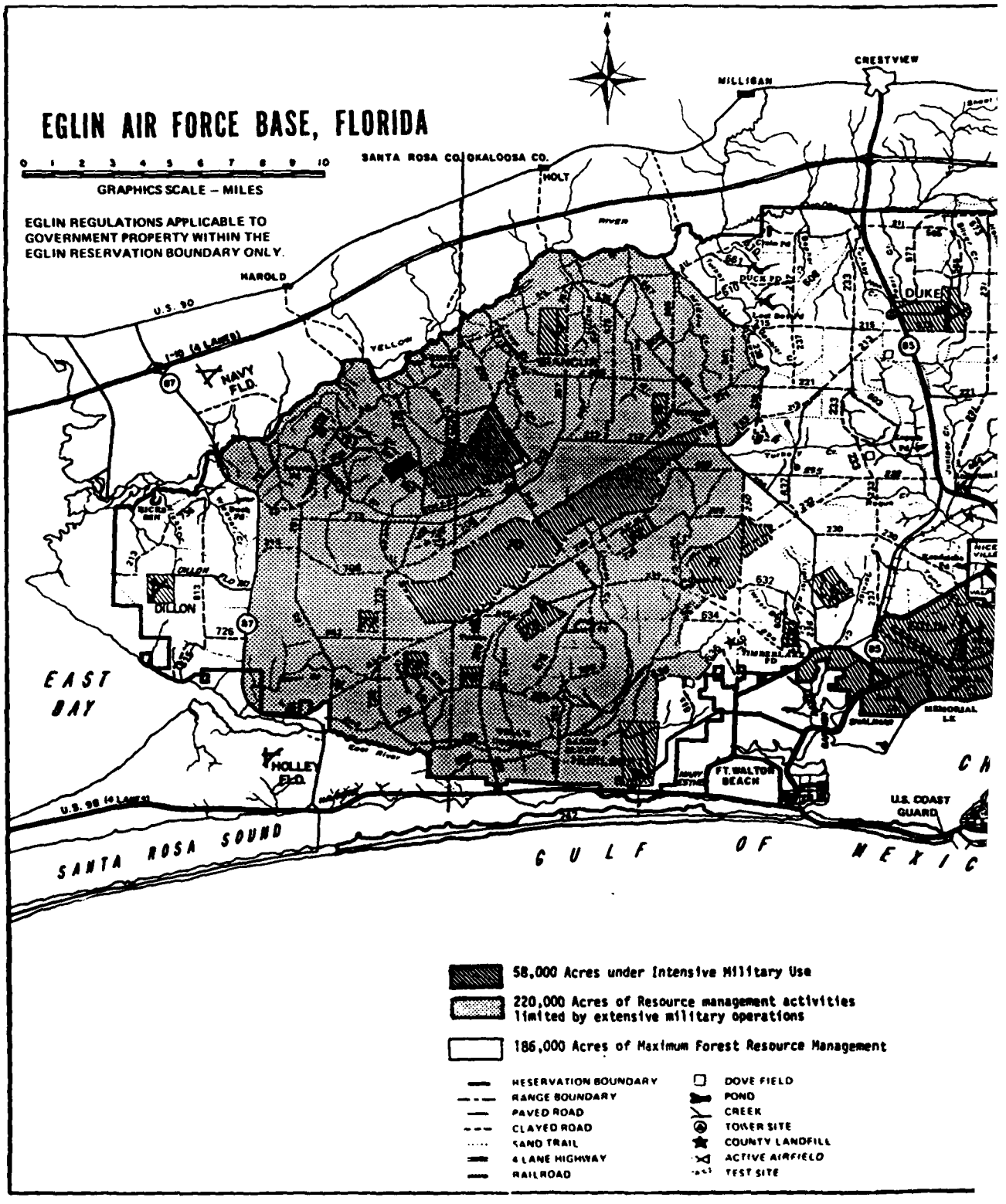
private burial sites (both active and inactive). There are certain "long-used roads" which are actually trails. The biotic sub-group is comprised of large, defined, static areas which incorporate natural mature timber stands. These stands are designated as unique, other unique botanical associations and areas protected due to the presents of endangered, threatened, or rare animal species. The geological sub-group is relatively small and takes in one fossil bed and two unique springheads, all of which are defined and static. The archeological sub-group is the most unstable due to its nature. This sub-group is composed of 34 recorded sites and approximately 300 sites of high probability. These areas are definitely excluded from consideration for inclusion in the plantations, but the plantation can be in the immediate area.

The forested recreational areas, which are extremely large and comprise approximately half of the base, consist of designated hunting and camping zones. (Figure 5). These areas are for the most part available for limited inclusion into the energy plantation.

The managed timber areas are located throughout the base and encompass areas that are also utilized for other activities, both military and non-military. The extent to which these areas are managed or utilized will vary greatly but the locations are well defined with fixed boundaries and can be included in the energy plantations.

3. NON-FORESTED ACREAGE

As with the forested area, the non-forested acreage is utilized both for military and non-military purposes with the military usage being predominate. Militarily, these "cleared" areas are used for certain testing and firing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ACTIVE AIRFIELD
TEST SITE

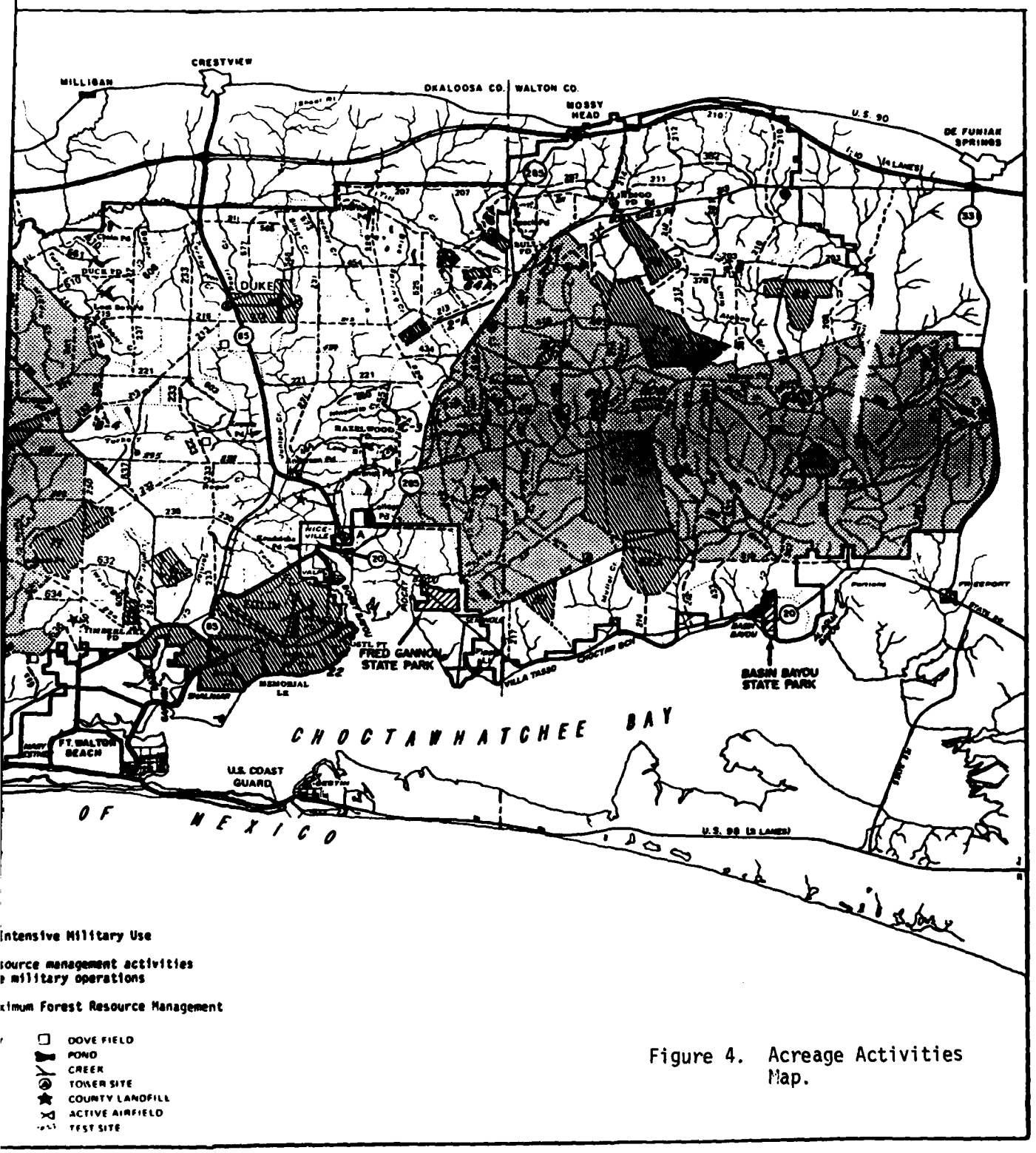

Figure 4. Acreage Activities Map.

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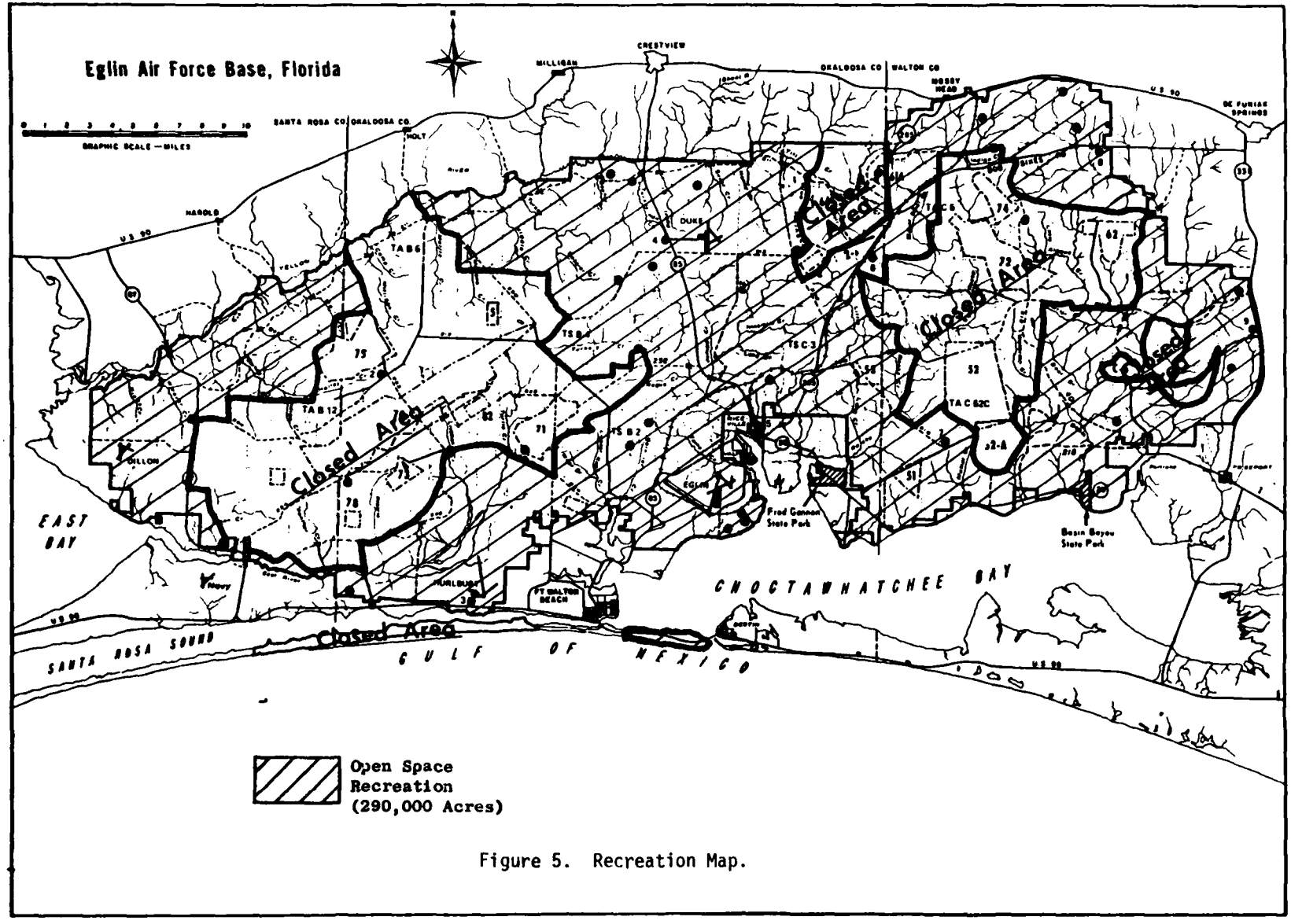

Figure 5. Recreation Map.

ranges, the main base and associated housing, auxiliary air fields, and the road system. All of these areas are well defined and will remain static so long as the base's mission is not altered or the operational level changed significantly.

The remaining non-forested acreage on Eglin is utilized for non-military purposes and is comprised of a federal prison facility and recreational areas. The federal prison facility is located on the Main Base complex and a new facility is currently under construction in the vicinity of Duke Field (Auxiliary Field No. 3). Neither of these facilities utilizes more than a few acres and will not expand in area significantly. The non-forested recreation areas do not approach the forested recreation areas in magnitude but are nevertheless substantial. These areas are the golf course, campgrounds, riding stable and trails, swimming and fishing areas, the skeet range, etc. The largest recreation areas are the dove hunting sites which have been created in various locations throughout the base by clearing several acres of forest and keeping them clear except for the grasses and other natural ground cover. Their location and growth depends upon usage and the number of assigned military personnel. None of the non-forested areas are considered for inclusion in the energy plantation.

A realistic view is to consider the stability of this acreage division in the context of the base mission requirements, and, at a minimum, maintaining the status quo with respect to base community relationships and, service/facilities provided. Additionally the following two assumptions have been made: 1) the base's mission will not substantially be altered as to its character; and 2) the operational level will not be increased beyond what would be considered normal growth. From this perspective, the basic division of forested and non-forested land, in terms of magnitude, is anticipated to remain relatively stable. No doubt there will be change in the next 40-60 years. However, the changes are more likely to be the shifting of certain test sites/ranges for new locations or an occasional additional test site/range being created as opposed to major changes in recreation areas or the physical structures on base. This type of change will have little effect on the actual number of forested or non-forested acres even though the complexion of certain areas may be changed.

If the commitment is made by the Air Force to make Eglin AFB a BEI, sufficient land is available to meet the biomass fuel needs. Land use patterns can be modified as necessary to accommodate all activity.

4. IDENTIFICATION AND QUANTIFICATION OF ACREAGE FOR ENERGY PLANTATION

The size of the area required for the energy plantation is approximately 90,000 acres. These areas need not be contiguous nor excluded from other activities but must be sized and located in such a manner as to be economically and feasibly managed.

In the identification of the acreage to be included into the energy plantations a minimum of four criteria had to be met: 1) non-interference with military operations; 2) good access by road; 3) reasonable transportation distance considering quantity of biomass to be removed; and 4) environmental impact of managing the area.

In order to maximize the likelihood of identifying areas which would not interfere with military operations or would be the least objectionable, meetings were held with the 3246 Test Wing staff. The results were that, operationally, unrestricted use could be made of base forestry management Compartments 2 and 4 (Figure 6). This area is presently designated as the Federal Aviation Administration air corridor for Okaloose County Airport and is already in extensive forest management. Any moderate amount of additional acreage that may be needed could be located in certain fringe areas of the compartments adjoining 2 and 4 (Figure 7) and possibly certain of the fringe areas along the base's outer boundary. These areas can be used without conflict.

Management Compartments 2 and 4 are bounded by Route 85 on the west and Route 285 and Bob Sikes Road on the east. This area accounts for approximately 77,800 (Reference 1) gross forested acres, however, not all can be used in energy plantations. From this total, 23,300 acres must be subtracted due to its current use, soil type or poor terrain conditions, etc., leaving 54,800 gross acres as a base. Certain archeological and environmental concerns must be deducted from the base. In Compartments 2 and 4 there are approximately 72 potential archeological sites and 40 red cockaded woodpecker colonies which will reduce the base by another 2,000 acres (Reference 2). Additionally, another 1,800 acres may be deducted for wildlife coordination (Reference 3). These deductions total 3,800 acres which leave a net area for energy plantations of about 51,000 acres depending upon the amount set aside for wildlife coordination. It should be noted that of this area, some 21,400 acres are currently in pine plantations.

It is apparent that Compartments 2 and 4 alone cannot support the total acres that are necessary for the energy plantations. An additional 40,000 net acres are necessary for the 90,000 net acres stated previously. This acreage is available in existing pine plantations that are located throughout the base in other forestry management compartments. This amounts to approximately 47,800 additional net acres and complies with the criteria established for energy plantations. If this amount is included with the net total from Compartments 2 and 4 then approximately 98,800 net acres are available to be put into managed energy plantations.

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[1]Model Forest Management Plan, Eglin AFB, Florida, Eglin AFB Florida: Natural Resources Division, Office of the Base Civil Engineer, February 1980.

[2]Consultation with Louis Tezar, Archeologist, Florida Division of Archives, History and Record Management, November 23, 1981; and consultation with Dick Thompson, U.S. Forest Service, November 23, 1981.

[3]Wildlife coordination guidelines established by the U.S. Forest Service for sand pine management in Ocala National Forest in Florida, June 1979.


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RESERVATION BOUNDARY
RANGE BOUNDARY
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CLAYED ROAD
SAND TRAIL
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CREEK
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COUNTY LANDFILL
ACTIVE AIRFIELD

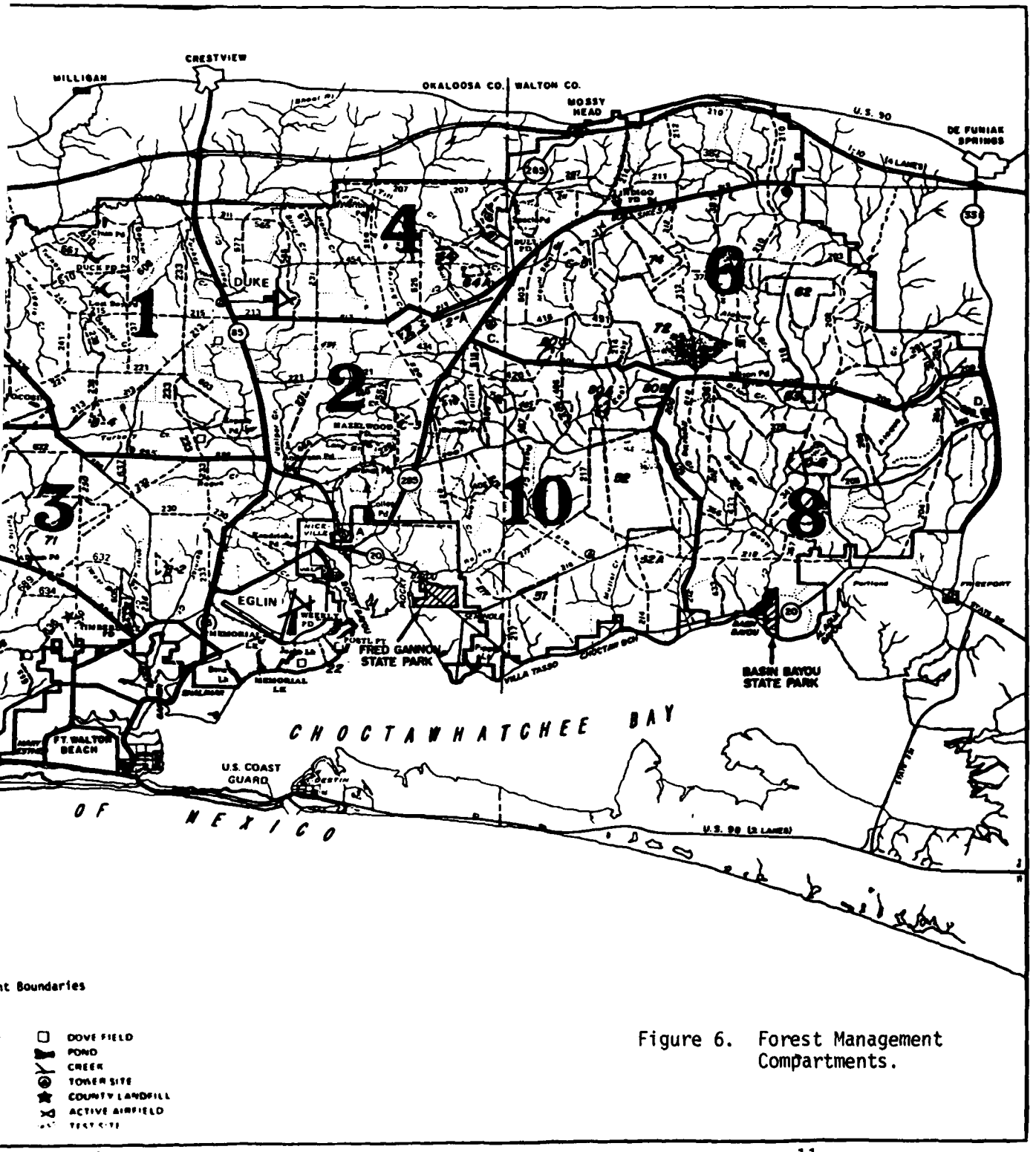

Figure 6. Forest Management Compartments.

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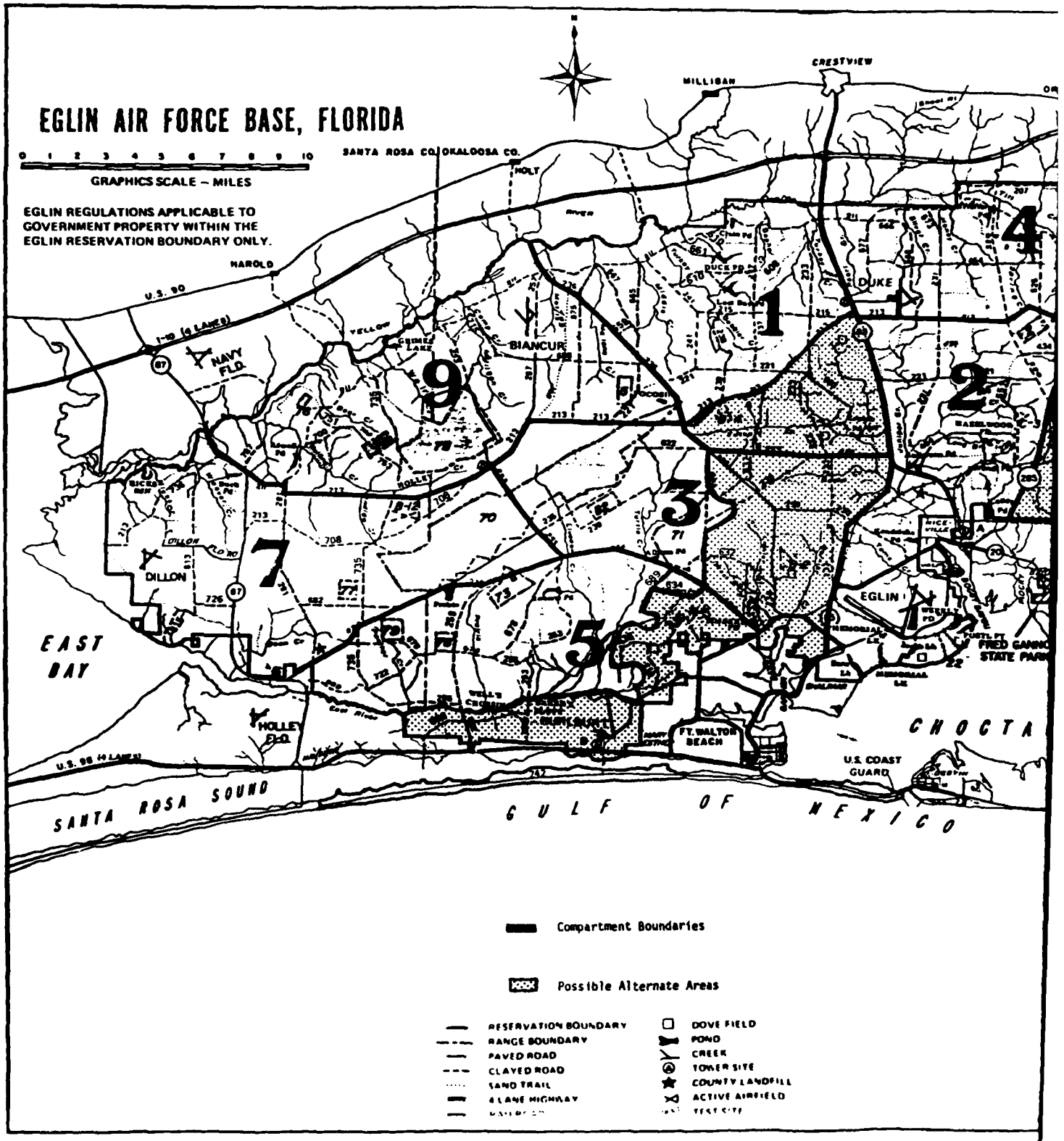
EGLIN AIR FORCE BASE, FLORIDA
0 1 2 3 4 5 6 7 8 9 10
GRAPHICS SCALE – MILES
EGLIN REGULATIONS APPLICABLE TO GOVERNMENT PROPERTY WITHIN THE EGLIN RESERVATION BOUNDARY ONLY.
SANTA ROSA CO.
OKALOOSA CO.
MILLIGAN
CRESTVIEW
HOLT
HAROLD
U.S. 90
I-10 (6 LANES)
NAVY FLD.
BIANCUR
DUKE
EGLIN
DILLON
HOLLEY FLD.
FT. WALTON BEACH
U.S. COAST GUARD
FRED GANNO STATE PARK
EAST BAY
SANTA ROSA SOUND
GULF OF MEXICO
CHOCTA
1
2
3
4
5
7
9
Compartment Boundaries
Possible Alternate Areas
RESERVATION BOUNDARY
RANGE BOUNDARY
PAVED ROAD
CLAYED ROAD
SAND TRAIL
4 LANE HIGHWAY
DOVE FIELD
POND
CREEK
TOWER SITE
COUNTY LANDFILL
ACTIVE AIRFIELD

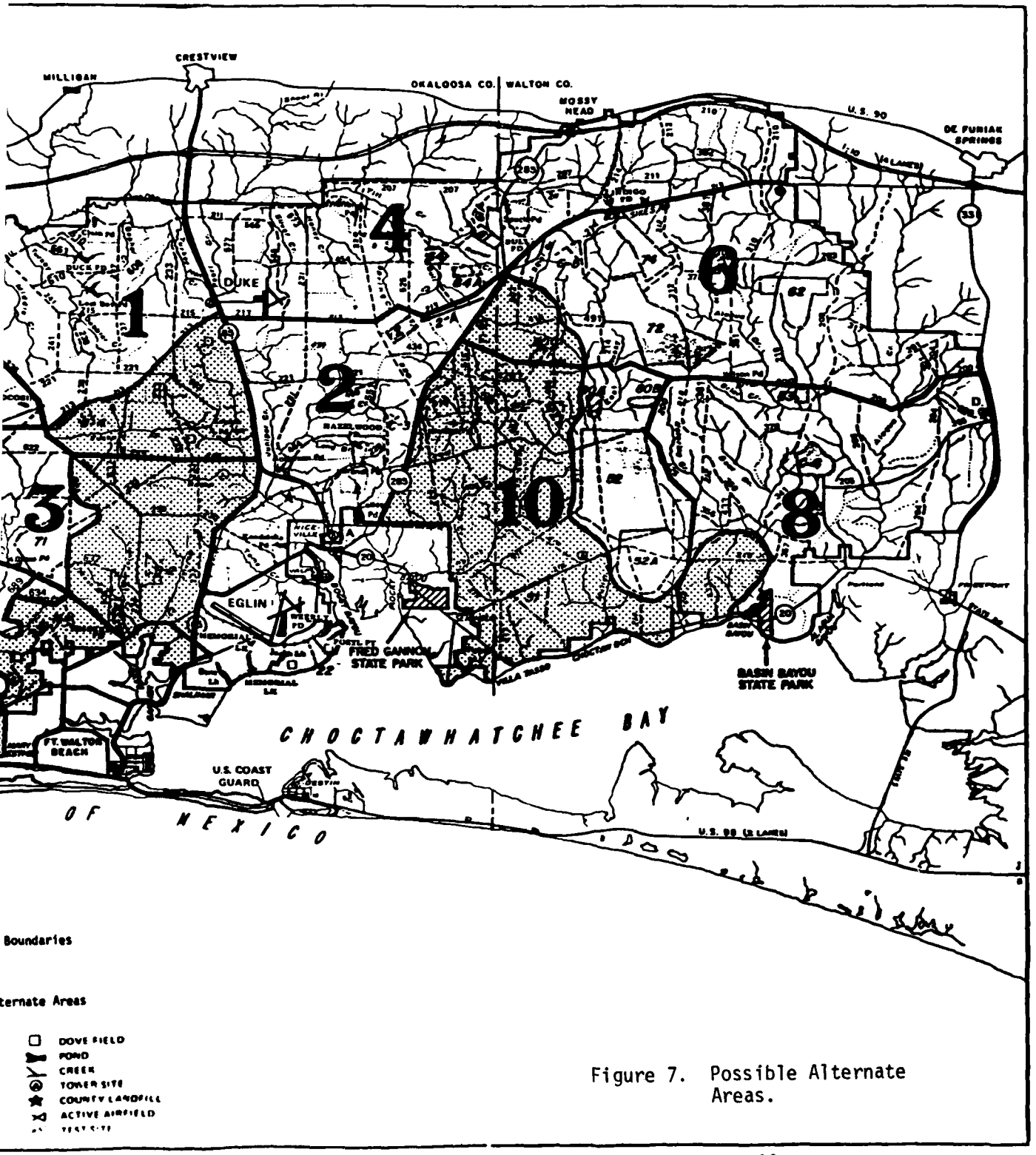

Figure 7. Possible Alternate Areas.

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TABLE 1. ENERGY PLANTATION ACREAGE SUMMARY

	ACRES
COMPARTMENTS 2 AND 4 (TOTAL)	77,800
REJECTED ACREAGE	-23,000
	54,800
SPECIAL INTEREST AREA	- 2,000
	52,800
WILDLIFE COORDINATION AREAS	- 1,800
	51,000
PINE PLANTATIONS OUTSIDE COMPARTMENTS 2 AND 4	+47,800
TOTAL NET ACRES BASEWIDE	98,800

Of equal importance with the identification and quantification of usable land is access to these areas. The extensive road system currently in place at Eglin is more than capable of accommodating any transportation traffic level requirements that would result from managing or harvesting the energy plantations (Figure 8). The road construction and planning is such that it can provide for the movement of the forestry equipment that would be used without any serious deterioration of the system. This has been accomplished in part by reinforcing any problem areas with asphalt or by rebuilding with clay (Figure 9).

Figure 9. Typical Timber Access Road.

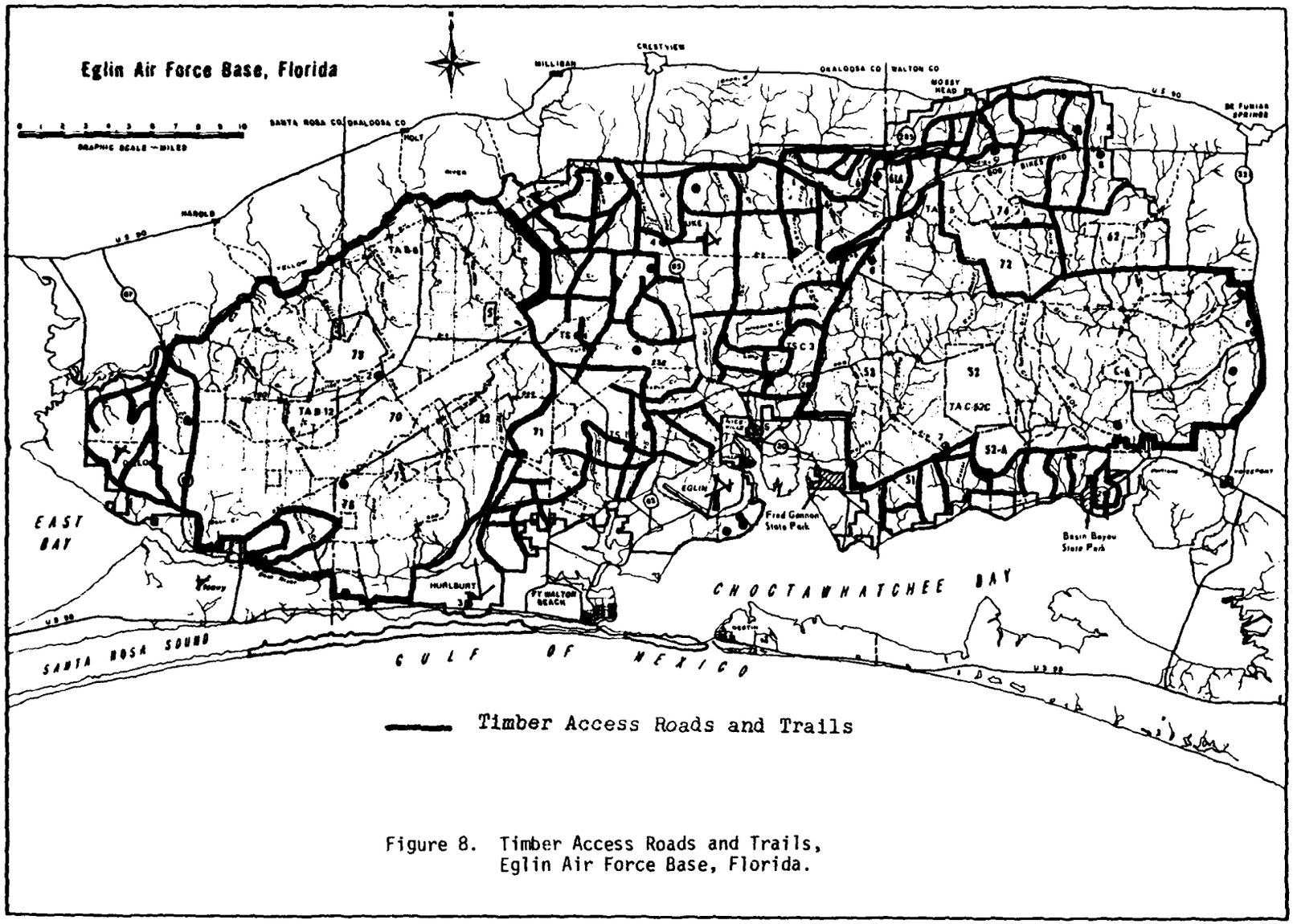

Figure 8. Timber Access Roads and Trails, Eglin Air Force Base, Florida.

5. ALTERNATE OR BACKUP ACREAGE

In addition to the acreage already identified for the energy plantations, there exists a great deal of acreage which can be utilized as alternate, backup or reserve areas. These locations are situated throughout the installation in areas that are not suited to military operations. One area that is particularly appealing for inclusion in this alternate area concept is the southern boundary which currently is not being utilized for any base activity.

SECTION III

ENERGY PLANTATION OPTIONS AND SPECIES

1. INTRODUCTION

An investigation of biomass production opportunities at Eglin has revealed five methods which have potential as energy wood management systems. These methods are not mutually exclusive and they should be regarded as options, rather than alternatives. The options which are recommended are complementary production modes. They can be used in an appropriate combination to produce energy wood reliably and cheaply, with acceptable environmental impacts. They will use the existing sites efficiently and maintain, or increase, the output of conventional forest products. The five options are listed below:

1. High Energy Subsidy with intensive crop management
2. High Energy Subsidy by sewage effluent application with intensive crop management
3. Low Energy Subsidy, single species, modified/conventional management
4. Low Energy Subsidy, dual species, modified/conventional management
5. Low Energy Subsidy, select single species, short rotation management

The process of identifying and evaluating options was greatly facilitated by the extensive research which has been done by Southeastern Forest Experiment Station (USDA, Forest Service) cooperating with the University of Florida at the Marianna (Florida) Research Center. This center has specialized in research on management of the northwest Florida sand hills, with special attention to the biomass potential of sand pine. At Eglin AFB, on-the-ground plantings in the various option species, installed over the past quarter century, allow a realistic assessment of the area's potential. These factors permit a high level of confidence in the findings and conclusions which are presented in this report.

2. ENERGY PLANTATION OPTIONS

a. High Energy Subsidy, with Intensive Crop Management

Under this option genetically superior trees of selected species (hardwood) would be grown at high density stocking and on very short rotations (about 5 years) under intensive management. Management practices would include cultivation, irrigation, and fertilization -- all of the crop management practices normally used in growing field crops. Capital investment costs would be high as would operating costs. Yield per acre would be higher than for any of the other options considered except Option 2 where sewage

effluent application is used. This mode would be particularly appropriate where land suitable for biomass production was in short supply or where the land was also needed for the production of food and feed crops.

Research is underway on such intensively managed silvicultural biomass farms at the University of Georgia and at Rhinelander, Wisconsin. Also, the Mitre Corporation is installing a 1,000 acre prototype plantation as a Department of Energy research project in Aiken, South Carolina (Reference 4). Many questions regarding the specifics of high energy subsidy farming remain unanswered, therefore, commitment to this option is not considered, at this time, to be appropriate at Eglin AFB.

b. High Energy Subsidy, Sewage Effluent Application with Intensive Crop Management

This option is essentially the same as standard crop management, except that effluent from wastewater treatment is used as the irrigating and fertilizing agent. Initial capital investment and operating costs could be moderate to high (depending on facilities in place). While the energy subsidy in the form of irrigation and fertilization is high, it is "free" in that it uses a "waste" material, the disposal of which is normally a problem. At Eglin AFB, such use would permit more efficient on-base use of some 2 million gallons of effluent produced daily.

No in-depth research on effluent use for biomass production has been done in the southern United States (Reference 5). While insufficient effluent volume is available from Eglin Air Force Base and the surrounding communities to support the production of a significant biomass volume, the use of this option does have appeal in its research possibilities and the rather general applicability of findings to other air force installations. Another possibility for effluent use is as an application in the seedling nursery, discussed later in this section.

c. Low Energy Subsidy, Single Species, Modified/Conventional Management

Under this option, management is aimed at the end production of conventional forest products (pulpwood, poles, sawlogs) but significant modification is made in the normal management practices to provide for the planned production of energy wood. The species used would be appropriate to the site. These modifications might include:

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[4]Ann S. Fege, Robert E. Inman, and David J. Salo, "Energy Farms for the Future," Journal of Forestry, Vol. 77, No. 6, June 1979.

[5]Wayne H. Smith, Don M. Post, and Frederick W. Adrian, "Waste Management to Maintain or Enhance Productivity; Impact of Intensive Harvesting on Forest Nutrient Cycling," Proceedings SUNY College of Environmental Science and Forestry, Symposium August 1979.

(1) Shortening rotations to permit a larger fraction of the stand life to be in the first decade; the energy wood production segment of the wood production cycle.

(2) Direct or broadcast seeding rather than planting. The aim of energy management is to ensure the maximum number of stems per acre in the earliest years, so as to fully utilize solar energy which would otherwise fall upon bare soil or be captured by non-usable weeds or grasses.

(3) A greater emphasis on natural regeneration (using seed tree or shelterwood techniques) as opposed to artificial regeneration. This is not only more energy efficient but usually results in the desired higher stocking rates mentioned above.

(4) An early "energy" thinning (at age 10 or 15) to place the young stand in good growing condition. This thinning would be the equivalent of what is now called a precommercial thinning.

This option is a practical and immediately applicable method of increasing energy biomass production at Eglin AFB. It is consistent with present policies, can be accomplished at minimal costs and lies within the present state of the art. However, the option could not produce the energy wood needed to achieve the Biomass Energy Island (BEI) goal on the land available.

d. Low Energy Subsidy, Dual Species Modified/Conventional Management

An option relying exclusively on artificial regeneration and incorporating the seeding of a fast growing energy species in conjunction with the establishment, by planting, of superior genetic stock of the final crop species. This plantation design has been proposed by Peter Koch (Reference 6). While most foresters consider this concept as futuristic, the principles espoused by Koch will most certainly be a part of standard forest management in the south long before the year 2020. This option cannot presently be considered operational, but testing of some of the principles, on appropriate sites, would be a desirable inclusion in this project.

Of special interest is the possibility of using the best sites on Lakeland soil to grow widely spaced genetically superior longleaf pine on a sawlog rotation in combination with multiple croppings of short rotation sand pine. Stands representing unplanned variations of this management technique are found on the base and offer some insights as to the appearance and potential of dual species management (Figure 10). The dual production of energy wood and conventional forest products would be of special interest to the local forest product industry and for this reason is recommended for early testing.

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[6]Peter Koch, "Concept for Southern Pine Plantation Operation in the Year 2020," Journal of Forestry, Vol. 78, No. 2, February 1980.

Figure 10. Dual Species - Slash Pine with Sand Pine Understory

e. Low Energy Subsidy, Select Single Species, Short Rotation Management

Lakeland soils comprise 75% of the soil type on Eglin AFB. This soil type provides the poorest classification for manageable forest land. Practically all of this area is part of the "sandhills"; and is comprised of deep, infertile sands of the Lakeland series. Originally, these soils supported stands of longleaf pine which were logged and destructively used for naval stores production early in this century. Today this extensive area of rolling sand hills supports a sparse growth of pines scattered through stands of commercially valueless scrub oak or other unsaleable low quality hardwoods as shown in Figure 11.

Dollars invested in clearing this land and reforesting it to slash or longleaf pine have offered less promise for an acceptable and prompt return than work done on better sites. As a result, available funds have often gone to more attractive investment chances and the sandhills of northwest Florida (both at Eglin and on adjoining private industry lands) have been undermanaged. In the past decade, a major change in sandhills management has taken place. Research has shown the Choctawhatchee sand pine, previously a little-regarded species found on the poorest, dryest soils along the gulf coast, has great capability for the production of biomass when grown on Lakeland soils (Figure 12). Local forest industries have planted sand pine

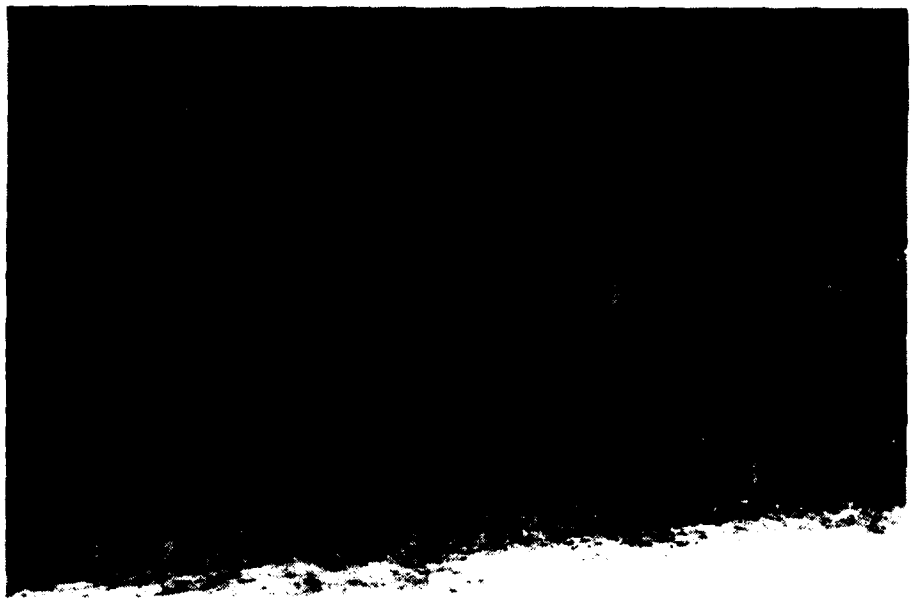

Figure 11. Scrub Oak.

Figure 12. Slash/Sand Pine (in Center) Stands Same Age. (SEFES Planting, Clarksville, FL)

extensively for pulpwood production on their lands adjacent to Eglin AFB. The most recent research findings shows an actual annual production of over 7 green tons per acre per year from this species (Reference 7).

The emergence of sand pine as a recognized high volume producer of the sandhills has coincided with the development of interest in biomass energy production. The two phenomena have met fortuitously at Eglin AFB, where the Sand Pine, Lakeland Soils options offers the single greatest promise for energy plantation management. High density stands produced by artificial seeding on the poorest Lakeland sites and managed on a short rotation (10 years) will produce the biomass necessary to fuel the base's energy facilities. This can be accomplished at minimal cost using presently perfected techniques (Figure 13).

Figure 13. Experimental Sand Pine Stand.
(SEFES Planting, Bristol, FL)

3. SUPERIOR OPTION SELECTION

Each of the five options have been evaluated in terms of 14 parameters which were selected as being the most significant of the many possible decision influencing factors. This evaluation is in Table 2.

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[7] D. L. Rockwood, et al., "Biomass Production of Densely-Planted Choctawhatchee Sand Pine," USDA Forest Service Research Paper SE-293, 1979.

TABLE 2. EVALUATION OF ENERGY BIOMASS OPTIONS, EGLIN AIR FORCE BASE.

OPTIONS \ ATTRIBUTES	ENERGY SPECIES	PRODUCTION GTPA/Y	ROTATION LENGTH (YRS)	COMPARATIVE MANPOWER NEEDS	EQUIPMENT & DEVELOP. NEEDS	ENERGY SUBSIDY REQUIREMENTS	NUTRIENT DEMAND/ DEPLETION	AGGREGATE ENVIRON-MENTAL IMPACT	EXPORTABILITY OF RESULTS	PRODUCTION OF CONV. FOREST PRODUCTS	KEY FACTORS: AREA NEEDED BEI (THOUSAND AC.)	KEY FACTORS: RELATIVE COST PER MMBTU	KEY FACTORS: STATE OF THE ART	KEY FACTORS: EVALUATION CONFI-DENCE LEVEL	KEY FACTORS: PRIORITY FOR IMPLEMENTATION
HIGH ENERGY SUBSIDY 8/ INTENSIVE CROP MANAGEMENT	HDWD	16	6	HIGH	HIGH	HIGH	HIGH	HIGH	YES	NO	34	HIGH	FUTURE	50	5
HIGH ENERGY SUBSIDY 9/ SEWAGE EFFLUENT APPLICATION	HDWD	16	6	HIGH	HIGH	HIGH "FREE"	HIGH	HIGH	YES	NO	N.A.	MOD/ HIGH	FUTURE	60	4
LOW ENERGY SUBSIDY SINGLE SPECIES	PINE	1	40	LOW	MOD	LOW	LOW	LOW	YES	YES	540	LOW	NOW	95	3
LOW ENERGY SUBSIDY 10/ DUAL SPECIES	SAND PINE	2½	50/ 10	LOW/ MOD	MOD	LOW	LOW/ MOD	LOW/ MOD	PART*	YES	216	LOW	NEAR FUTURE	90	2
LOW ENERGY SUBSIDY 11/ SELECT SINGLE SPECIES	SAND PINE	6	10	LOW/ MOD	MOD	LOW	MOD	MOD	PART*	NO	90	LOW	NOW	98	1

PREFERRED OPTION

GENERAL NOTE:
No body of substantive research or experience exists for many of the factors considered in this evaluation. For such factors (e.g. nutrient demand/depletion, cost per MMBtu, aggregate environmental impact) the evaluation is based on applied biologic and economic principles and on local conditions interpreted by the evaluator's professional judgement. Definitive evaluation of these and many other unknowns would be a significant benefit resulting from the Eglin BEI project.

* Species specific but with exportable principles.

8/ D.J. Salo, et al., "Design of a Pilot Silvicultural Biomass Farm at the Savannah River Plant", MITRE, 1979.

9/ Wayne H. Smith, et al., "Waste Management to Maintain or Enhance Productivity; Impact of Intensive Harvesting on Forest Nutrient Cycling", Proceedings SUNY College of Environmental Science and Forestry, Symposium August 1979.

10/ Peter Koch, "Concept for Southern Pine Plantation Operation in the Year 2020", Journal of Forestry, Vol. 78, No. 2, February 1980.

11/ D.L. Rockwood, et al., "Biomass Production of Densely-Planted Choctawhatchee Sand Pine", USDA Forest Service Research Paper SE-293, 1979.

Of the 14 variables, four (Area Needed, Relative Cost per MMBtu, State of the Art, and Confidence Level) are regarded as key factors. If an option required more area to meet BEI requirements than was available on Eglin AFB, then that option could not be considered as preferred. A relatively low cost per MMBtu would, of course, be a strong argument for adopting an option. A state of the art which would permit immediate or near term implementation is an imperative, while a high confidence level (an expression of security in findings and of the option's probability for successful implementation) is a prerequisite for the very large resource investments which this project will require.

Options 1 and 2 (High Energy Subsidy) were eliminated because of their high MMBtu cost and the questions surrounding the practicality of their technology. Option 3 (Modified/Conventional) would require an acreage greater than the entire Eglin AFB, hence it was dropped from consideration. Of the two remaining options, the Select Single Species, Option 5 was selected as the preferred option because of its superiority in all of the key factors. This option also rates satisfactorily in all of the other 11 variables except for "the production of other forest products." Other species will have to be managed for the commercial markets as required. Option 4 (Dual Species) does provide for the production of conventional forest products and for this reason we recommend that it be considered as a probable complemental mode to Option 5. It offers an opportunity for substantial energy wood production, while at the same time supporting local forests products industries and utilizing to full advantage the best of the Lakeland soil sites.

In summary, Option 5 (Sand Pine/Lakeland Soil) is the preferred and recommended option. Eglin's energy wood requirements can be grown reliably and cheaply under this option. Option 4 (Dual Species) offers promise as a complement to Option 5. It could be used on the best Lakeland soils sites to produce both energy wood and conventional forest products. Option 3 (Modified/Conventional) can be used as needed to produce small amounts of energy wood. Option 2 (Effluent Application) would be chiefly valuable as a research project on a small tract, while Option 1 (High Energy Intensive Management) is not recommended for use in any form at this time.

All of the options will involve land clearing, the removal of existing vegetation. Under current management, the merchantable material (pine sawtimber and pulpwood) is sold and removed in a commercial logging operation. The land is then "site prepared" (Figure 14) for planting or seeding by chopping (crushing and cutting by a large fin-type rolling drum) the unsaleable hardwoods at a cost of $35 to $60 per acre. This currently unused material, amounting to perhaps 10 green tons per acre, would be harvested and used for energy production in an operating biomass production system, saving site preparation costs while providing an immediate energy return from the land. This one-time yield can provide feedstock during the early low consumption phase-in of generating facilities, prior to the first cuttings from the energy plantations.

a. Seed Supply for Selected Option

In order to maintain the seeding and replanting of presently harvested areas, large amounts of pine seeds are purchased from either the Florida Division of Forestry or the Alabama Forestry Division. In many instances the

Figure 14. Site Preparation.

seeds which are available are not the desired species or are in short supply. With the increased need of acreage to be replanted each year, due to the energy plantations, it is doubtful that sufficient quantities of seed would be available for purchase. Accordingly, it is recommended that a base tree nursery, seed extraction and storage facility be incorporated into the silvicultural planning for the purposes of producing sufficient and high quality seeds.

The following conditions should be taken into account:

(1) Under the BEI concept and the Option 5 recommendation an adequate supply of seed or seedlings is essential.

(2) Current suppliers probably will not be willing or able to meet the increased requirements.

(3) An on base nursery will allow the forestry staff to conduct experimental projects such as effluent application and it will give them the opportunity to develop superior species for the base.

(4) It is possible that a cost savings may be realized and there is a potential revenue production from outside seed sales.

(5) The seed extraction, processing and storage processes may require specialized personnel which could be obtained on a contract basis.

(6) The nursery could most likely be operated by existing staff supplemented by a labor force from the federal prison facility.

Concerning the last item, discussions were held with Mr. Willis of the prison staff and this concept was given encouragement. It would allow more inmates to become productive and perhaps gain specialized skills. The Forestry Department currently uses more than 20 inmates and sees no problem with utilizing 15 to 20 more to work in the nursery and seeding operations. All of these operations would be on base and removed from populated areas.

This base nursery concept would enable the base forestry personnel to control the complete cycle from nursery stock selection, planting, testing, and stand improvement through determining which stands will be used for merchantable timber and biomass fuel for Eglin. The costs of the nursery operation would be covered by the timber sales to sawmills, pulp and papermills and the savings generated from not purchasing the seeds on the open market.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

This study has identified and quantified 98,800 net producing acres that can be adequately managed and placed into biomass energy plantations with the capability of supporting Eglin AFB as a Biomass Energy Island. This acreage should be available for use as energy plantations on a long-term basis with little or no interference with any military operations or exercises.

The amount of timber that can be produced on the identified acreage in energy plantations will, after the initial cycle has been completed (6-10 years), supply more than could be utilized for fuel. Once this point is reached, either the excess acreage could be released from the plantation for use in some other activity or the excess timber could be sold commercially as fuel wood or to the local mill owners by allowing them to increase their harvesting.

With proper planning and management the Biomass Energy Island concept can become a reality at Eglin without adverse effects on the environment, the wildlife, or the special interest archeological, historical, and geological areas. In fact, a fully coordinated wood energy program should enhance wild life habitat and minimally impact on the visual and recreation resources.

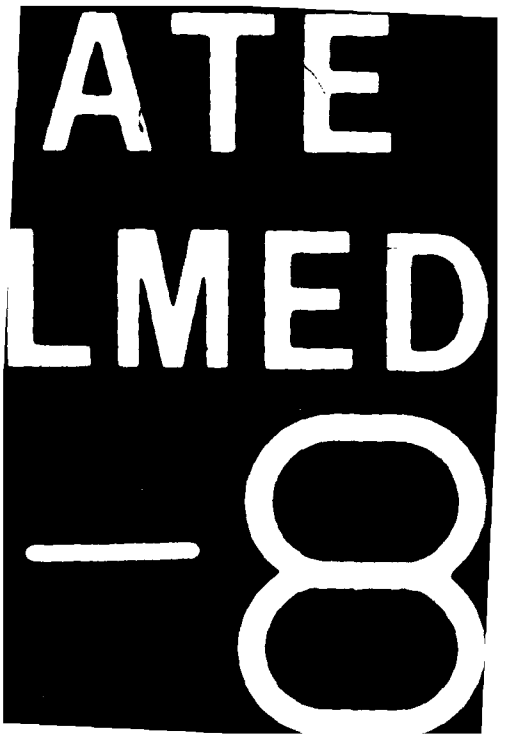
2. RECOMMENDATIONS

a. Additional Investigative Studies

To date all efforts directed at studying the Biomass Energy Island concept at Eglin AFB have proven positive. Further effort is still required in other related areas such as institutional and statutory barriers to intensive forest management; development of wood energy related forest management policies and plans; work force requirements; and the selection of harvesting, transportation, and fuel handling equipment. The remaining efforts needed to finalize this entire process should be initiated as soon as is practicable.

b. Biomass Production StartUp

In the interim, to enable the production of biomass to meet the initial demand, planning for and initiation of the forest management for fuel wood should begin immediately. In essence, the base forestry staff should be given the direction to take the first steps necessary in providing energy self-sufficiency. This is a vital aspect to a program of this nature due to the length of time required between planting and harvesting.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